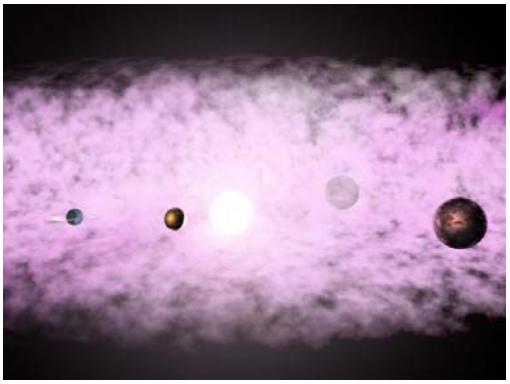

Introduction to the Solar System

This trunk contains a variety of materials and lessons for use when teaching about the solar system. This introductory section provides over-arching information on the origin and composition of our solar system. Interspersed are references to more specific lessons and use of the visual aids and resources provided. One valuable resource included is a PowerPoint Presentation that can be used simultaneously while teaching this module. We suggest you read through this entire section before presenting it to become familiar with the content of lessons and places where additional resources are useful.

Grade Level: 4th –12th

Objectives:

- Understanding formation and structure of the solar system
- Identification of solar system components
- Comprehending scale of the solar system and its components, including distance, size, and mass
- Distinguishing between planetary objects
- Generating scaled models

Arizona State Standards:

- **6SC-P1. PO2.** Describe the processes explained by prominent scientific theories of the origin of the solar system

Time needed: 2-5 class periods

Lessons:

- Introduction to the Solar System lecture with accompanying PowerPoint Presentation
- The Edible Solar System
- Toilet Paper Solar System
- Solar System Mass Distribution
- Making a Comet

Visuals:

- Hubble Space Telescope image of galaxies
- Olympus Mons and Arizona comparison
- Olympus Mons and Hawaii comparison
- Valles Marineris and United States comparison
- Mars global photomosaic
- Mimas images
- An Asteroid Wiped out the Dinosaurs: What's next?

- NEAR spacecraft configuration
- Eros images

Resources:
- Secrets of the Universe Card Set (7 cards)
- NASA Solar System Lithograph set (15 cards)

Posters:
- Milky Way
- Discover the Solar System; Scholastic
- Mapping the Solar System; USGS
- Planetary Maps; USGS
- Sojourner; NASA
- Mars Pathfinder; NASA
- Galileo Arrival at Jupiter; NASA
- NASA's Galileo Spacecraft Explores Io; NASA
- Voyager images of Io; NASA/USGS
- Amazing Saturn; NASA
- Cassini Voyages to Saturn; Weekly Reader

Introduction to the Solar System:
PowerPoint Presentation (SSPRES.ppt) can be used along with the following outline. It is contained on a CD-Rom located on the back cover of this packet.

I. Our Galaxy: The Milky Way

Show the ***poster*** *of the Milky Way* to the class and explain it along with the following information

- **a.** Our **galaxy** is the Milky Way, composed of billions of stars one of which is the Sun (the center of our solar system). ***Demo****: Set the 5 lb bag of sugar on the table and put a small amount in your hand. Tell the class that if each sugar grain were a star, the bag of sugar would represent approximately the number of stars in our galaxy.*
- **b.** Ours is a spiral galaxy, it has arms (draw a picture). Other galaxies have elliptical or irregular shapes.
- **c.** Speed of light = 3.0×10^8 meters/sec (if the Sun went out, it would take 8 minutes to get dark on Earth).
- **d.** The Milky Way is one of about 100 billion galaxies.
- **e.** ***Visual:*** *Hubble Space Telescope image of galaxies*
- **f.** ***Resource:*** *Secrets of the Universe Card 3: Hubble Telescope*
- **g.** ***Resource:*** *Secrets of the Universe Card 2: Milky Way*

II. Solar System Formation

- **a.** Formed about 5 billion years ago from the collapse of a huge cloud of gas, the **solar nebula** (hydrogen, helium), dust (ices, oxides, iron), and matter.
- **b.** The cloud collapsed in on itself and pieces tended to smash into each other growing bigger and bigger until they formed the planets.

c. Most of the heat and energy remained in the center of the cloud, eventually, forming the Sun.
d. Denser rocky planets are closer to the Sun, lighter gas giants are farther from the Sun.
e. ***Demo:*** *digital movie clips* ***(solar_system_form.mov, planetesimals.mov, and solsystem.mov)*** *of the collapse of the solar nebula and accretion of planets included on CD-ROM in PPP directory.*
f. ***Resource:*** *Secrets of the Universe Card 9: The Solar System*

III. Inhabitants of our Solar System

In this section general information and interesting facts are presented about each of the planets, the Sun, and other solar system objects such as asteroids and comets.

a. Have students list the objects that can be found in our solar system. Some examples are:

- The Sun
- Planets
- Asteroids
- Comets, Oort cloud, Kuiper belt
- Moons
- Spacecraft, satellites, International Space Station, MAN
- ***Lesson:*** *Edible Solar System*
- ***Lesson:*** *Toilet Paper Solar System*.
- ***Resource:*** *NASA Litho - Our Solar System*

b. The Sun is

- A medium sized star (not a planet) made of helium and hydrogen
- About ½ way through it's life cycle, 4.5 billion years old
- The center of our solar system
- ~335,000 times more massive (bigger, more matter) than the Earth & contains 99.86% of the mass of the entire solar system – so everything is attracted to it, that is, gravitationally pulled toward it. We are all falling toward the Sun.
- ***Lesson:*** *Solar System Mass Distribution*
- 16,000,000° K (28,799,541°F) at it's core
- ***Resource:*** *Secrets of the Universe Card 12: The Sun*
- ***Resource:*** *NASA Litho - Sun*

c. The Planets

- 2 groups of planets – **rocky** (terrestrial) and **gas giants** (Jovian)
- Rocky planets – Mercury, Venus, Earth, Mars
- Gas giants – Jupiter, Saturn, Uranus, Neptune
- Pluto – could be a trapped asteroid knocked out of it's orbit by gravitational pull of a passing star or by the pull of Neptune
- ***Poster:*** *Discover the Solar System*
- ***Poster:*** *Mapping the Solar System*

- ***Poster:*** *Planetary Maps*
- ***Resource:*** *Secrets of the Universe Card 13: Seeking Planets*

Mercury

- A day on Mercury lasts 176 Earth days - because it takes 88 days to orbit around the Sun, faster than any other planet in our solar system, and it makes a complete rotation on its axis in 59 days
- Surface temperatures range from 800°F when facing the Sun to -301°F when facing away from the Sun
- It has a high diurnal flux because there is no atmosphere
- ***Resource:*** *NASA Litho – Mercury*
- ***Demo:*** *digital movie clip on the Caloris Basin* ***(merc2.avi)*** *included on CD-ROM in PPP directory*

Venus

- Named for the Roman god of love and beauty
- Hottest planet in the solar system – 860°F, hot enough to melt lead
- Hottest planet due to atmospheric greenhouse effect and atmospheric pressure
- Pressure at surface is 90x that on Earth's surface
- No space craft has ever lasted more than 2 hours on the surface before imploding
- Greenhouse atmosphere (thick clouds) cause high temp and pressure
- A Venus day is longer than it's year - Rotates once on it's axis every 243 Earth days while it orbits the Sun every 225 days
- Venus is the only planet that rotates backwards, i.e. clockwise (the Sun rises in the west and sets in the east)
- It rains sulphuric acid – because there are more volcanoes on Venus than we will ever be able to count
- The are more than 1 million volcanic centers on the surface of Venus
- Everything on Venus is named after women (a very few exceptions)
- ***Resource:*** *NASA Litho - Venus*

Earth

- Only planet with liquid water, oxygen rich atmosphere, and life
- Only planet with plate tectonics – constantly changing the planets surface, recycling the planets crust
- ***Resource:*** *NASA Litho - Earth*
- **Moon**
    - Earths only natural satellite
    - Stabilizes Earths wobble – precession (like the wobble when a top spins)
    - Most likely formed when a Mars sized body obliquely collided with the Earth ejecting material from both bodies. The body flew off but ejected debris remained in orbit around the earth and eventually accumulated to form the moon

- Dark areas – maria (basaltic lava plains, lavas that filled ancient craters)
- Light areas – anorthosite (volcanic) highlands
- No atmosphere
- No plate tectonics
- Only mechanical erosion from micrometeorites
- 240,000 miles from Earth
- ***Demo:*** *Use a standard globe to show the distance from the moon (4" ball) to Earth (240,000 miles at globe scale = 40'). Space Shuttle flies 200 miles above Earth (0.6").*
- ***Resource:*** *Secrets of the Universe Card 4: The Moon*
- ***Resource:*** *NASA Litho - Moon*

Mars

- Named for the Roman god of war
- Called the Red Planet because of iron oxide – rust
- Largest volcano in solar system – **Olympus Mons**, 16 miles high (16x taller than San Francisco Peaks) and 373 mi. across (size of Arizona). ***Visuals:*** *Olympus Mons and Arizona or Hawaii comparisons*
- Largest canyon in solar system – **Valles Marineris**, stretches from LA to NY, 2400 miles long, 4 miles deep. Formed by tectonic, extensional stresses, similar to East African Rift Valley. ***Visual:*** *Valles Marineras and United States comparison*
- Only other planet with polar ice caps, frozen CO_2 (dry ice) and some water
- Frozen water most likely exists underground and deep within the ice caps
- Moons - **Phobos and Deimos** – are probably captured asteroids
- 2 spacecraft currently orbiting – Mars Odyssey and Mars Global Surveyor
- Pathfinder landing in 1997
- ***Resource:*** *NASA Litho – Mars*
- ***Resource:*** *Secrets of the Universe Card 5: Cape Canaveral*
- ***Demo:*** *mpeg movies* ***(vdeimos3.mpg and vphobos3.mpg)*** *of Deimos and Phobos included in PowerPoint presentation and on CD-ROM under PPP directory.*
- ***Visual:*** *global photomosaic*
- ***Poster:*** *Sojourner*
- ***Poster:*** *Mars Pathfinder*

Jupiter

- Most massive planet in the solar system, its composition resembles a small star
- Core has a consistency of thick soup, a dense hot liquid
- It's stripes reflect strong E-W wind belts with storms
- The Giant Red Spot has probably existed for more than 300 years, it is a big storm. 3 Earths could fit in it.
- Jupiter has rings
- A gas giant (hydrogen and helium) with 28 moons

- ***Resource:*** *NASA Litho – Jupiter*
- 4 Galilean satellites
    - **Io** – only planet in the solar system with visibly active volcanoes, erupting only sulphur; ***Visuals:*** *Voyager images of Io.*
    - **Europa** – an ice covered water ocean could exist on this moon
    - **Ganymede** – largest moon in the solar system, larger even than the planet Mercury. First moon known to have its own magnetic field
    - **Callisto** – Extremely heavily cratered
- ***Resource:*** *NASA Litho – Moons of Jupiter*
- ***Poster:*** *Galileo Arrival at Jupiter*
- ***Poster:*** *NASA's Galileo Spacecraft Explores Io*

Saturn

- Named for the Roman god of agriculture
- 7 rings of ice and rock particles
- Stripes are wind belts, wind speeds up to 500 meters/second
- A gas giant (hydrogen and helium) with 30 moons
    - **Titan** – the largest moon of Saturn, bigger than Mercury; nitrogen rich atmosphere that may be similar to the Earth's long ago
    - **Mimas** – Star Wars Death Star planet
    - ***Visual****: Mimas images*
- Cassini spacecraft was launched in 1997 and will reach Saturn in 2004, it will deploy the Huygens probe to explore the surface of Titan
- ***Poster:*** *Amazing Saturn*
- ***Poster:*** *Cassini Voyages to Saturn*
- ***Resource:*** *NASA Litho – Saturn*

Uranus

- 3rd largest planet
- Blue color from methane gas
- It is so far from the Sun that its seasons are >20 years long
- Temps nearly -355°F at the cloud tops
- Axis of rotation is nearly horizontal – spins like a tire on a car. This tilted axis could be from a collision soon after formation, knocking the planet on its side
- Has rings: they are vertical because they parallel the planets equatorial plane
- ***Resource:*** *NASA Litho – Uranus*
- 21 moons
    - **Miranda** – 2 types of terrain - old heavily cratered and young complex terrain of scarps and ridges forming chevron features

Neptune

- Looks blue because of methane gas, not water
- Has rings
- Since its discovery in 1846, it has yet to complete one orbit around the Sun. Takes 164 Earth years to orbit the Sun
- Will complete it's first orbit since discovery in 2010
- It is the windiest planet, winds reach 1,243 mph
- ***Resource:*** *NASA Litho – Neptune*
- 8 moons
    - **Triton** – coldest surface in the solar system -391°F and only moon that orbits in the opposite direction as its parent planet. Gradually getting closer until it collides with Neptune creating more rings. Great nitrogen geysers are erupting on the surface.

Pluto

- Only planet never visited by a space craft because it is too far away
- Discovered in Flagstaff, Arizona in 1930 by Clyde Tombaugh at Lowell Observatory
- Takes 248 years to orbit the Sun, very elliptical orbit and not in the same plane as the other planets
- Only 1 moon, named **Charon,** discovered in 1978
- Might really be an asteroid ejected from the Kuiper Belt and captured by our Solar System
- ***Resource:*** *NASA Litho – Pluto and Charon*

d. Asteroids

- Rocky fragments left over from the formation of the solar system (stony irons, chondrites, carbonaceous chondrites)
- 1 km to 1,000 km size range
- Most orbit the Sun in a region between Mars and Jupiter called the **asteroid belt**
- Asteroid belt probably contains millions of asteroids, so far 20,000 have been numbered
- Sometimes asteroids can get pulled out of their orbits by the strong gravitational forces of Jupiter and Mars and flung out into the solar system to impact with Earth or other planets. E.g. – Shoemaker-Levy 9, Meteor Crater, or Chicxulub, a rogue asteroid that hit earth ~65,000 years ago
- February 2001, **NEAR-Shoemaker** spacecraft made the first ever landing on an asteroid – **Eros**
- *NEAR-Shoemaker and Eros spacecraft images*
- ***Visual:*** *An Asteroid Wiped Out the Dinosaurs, What's Next?*
- ***Resource:*** *NEAR Encounter with Asteroid 433 Eros*
- ***Visuals:*** *NEAR spacecraft configuration, Eros images*
- ***Resource:*** *NASA Litho – Asteroids*

e. Comets

- Dirty, ice remnants from the formation of the solar system
- They are the least changed objects in our solar system so may yield important clues to the formation of the solar system
- 2 types – long period and short period
  - **Long period** comets come from the **Oort Cloud**
    - Located near the edge of the SS, 100,000 AU from the Sun (1 AU is distance from Earth to Sun, i.e. 93 million miles)
    - Oort Cloud may have 1 trillion comets
    - These comets can take up to 30 m.y. to make 1 orbit around the Sun
  - **Short period** come from the **Kuiper Belt**
    - Kuiper Belt is just past the orbit of Neptune
    - These comets take under 200 years to orbit the Sun
- They have a tiny solid nucleus containing icy chunks and frozen gases with fragments of rock and dust, they may also have a small rocky core
- Comets melt when they get too close to the Sun
- Comets have a tail, called a coma, formed by fountains of gas and dust that get released as the Sun heats the ice. These tails can extend for 1,000's of miles and we see them from earth. The tails always point away from the Sun because of the direction of the **solar wind**.
- All comets have very elliptical orbits
- ***Lesson:*** *Make a comet with dry ice*
- ***Resource:*** *NASA Litho – Comets*

f. Edge of the solar system - marked by where our solar wind meets the interstellar wind

- **Heliopause** – where our Sun no longer has any influence on the wind
- Voyager spacecraft were launched in 1977, in 2004 they will pass through the heliopause
- **Firmament** – the hemisphere of sky and stars we see

Vocabulary:
Galaxy, solar nebula, solar system, rocky planets, gas giants, asteroid belt, Oort Cloud, Kuiper Belt, solar wind, heliopause, firmament

References and Additional Resources:

- NASA Spacelink/Our Solar System: http://spacelink.msfc.nasa.gov/Instructional.Materials/Curriculum.Support/Space.Science/Our.Solar.System/
- Scholastic space activities: http://teacher.scholastic.com/ilp/index.asp?SubjectID=4&SubheadID=8&TopicID=103
- http://www.nineplanets.org/
- Clay Planets: http://www.windows.ucar.edu/tour/link=/teacher_resources/clayplanets_edu.html
- Applet of solar system: http://burtleburtle.net/bob/physics/solar.html
- Solar System Exploration: http://sse.jpl.nasa.gov/education/education.html
- Planetary Photojournal: http://photojournal.jpl.nasa.gov/
- NASA Solar System: http://www.jpl.nasa.gov/solar_system/solar_system_index.html
- NASA Central Operation of Resources for Educators: http://core.nasa.gov/
- Exploring Planets in the Classroom: http://www.spacegrant.hawaii.edu/class_acts/index.html
- Mars Odyssey Homepage: http://mars.jpl.nasa.gov/odyssey/
- NASA/JPL Educator Page: http://www.jpl.nasa.gov/education/index.html
- Current Missions: http://www.jpl.nasa.gov/missions/missions_index.html
- USGS Flagstaff Field Center Space Science: http://wwwflag.wr.usgs.gov/USGSFlag/Space/space.html
- Nineplanets: http://www.seds.org/nineplanets/nineplanets/nineplanets.html
- A Solar System Scale Model Meta Page: http://www.vendian.org/mncharity/dir3/solarsystem/